UNIVERSITY OF ILLINOIS

URBANA, ILL.

BIENNIAL REPORT

OF THE

BIOLOGICAL EXPERIMENT STATION.

1895-1896.

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J. C. Winship Company, Printers.
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Biological Experiment Station.

ADMINISTRATION AND STAFF.

Andrew S. Draper, LL. D., President of the University.

Stephen A. Forbes, Ph. D., Dean of the University College of Science and Director of the Station.

Charles A. Kofoid, Ph. D., Superintendent of the Station and Zoölogist.

Arthur W. Palmer, Sc. D., Chemist.

Frank Smith, A. M., Assistant Zoölogist.

Charles A. Hart, Entomologist.

Adolph Hempel, B. S., Zoölogical Assistant.

Clendon V. Millar, M. S., Assistant Chemist.

Lydia M. Hart, Artist.

Miles Newberry, General Assistant.

BIENNIAL REPORT

OF THE

BIOLOGICAL EXPERIMENT STATION.

To the Trustees of the University of Illinois.

GENTLEMEN: The Biological Experiment Station of the University of Illinois was founded mainly to represent the university and the state in an important field of scientific investigation; to do its part towards making the people of the state at large acquainted with the state itself; to stimulate and to aid the educational activities of the public schools in respect to the biological subjects and to reform, in some respects, their methods; and to put a foundation of precise and comprehensive knowledge of the system of aquatic life under the practical art of the fish culturist, especially as this is represented by the operations of the fish commissions of our interior states.

It hardly need be said that an educational institution may not properly assume and keep the name of university which is content to depend wholly on the abilities and activities of others for the store of knowledge which it distributes to its students, contributing nothing on its own part to the common stock. Such a condition of complete dependence marks it as at best a secondary school. It is also beneath the dignity of a sovereign state to depend wholly on others for the fundamental elements of its welfare, making no effort to render any return in kind. On the other hand, a state university owes its first duty to the people of its own state, and should investigate by preference subjects which concern their welfare. Even though it may do valuable work in remoter fields, it neglects its own sphere of essential and immediate usefulness if it lets its own territory remain unexplored, and its own special problems lie without solution.

The teaching of biology has been for many years required in the public schools of Illinois, but it is a commonplace com-

plaint that this work is far less valuable than it should be, and that its progress is grievously hampered because most of our teachers of science have a very imperfect acquaintance with the subject matter which should be taught and with the most fruitful methods of biological instruction. The University of Illinois, through its Biological Station, can do a great service to education at this juncture by opening up our local natural history to teachers of elementary biology, and by making them acquainted in a thoroughly practical way with the most useful special methods in this field. We seem just now, indeed, in admirable position to lead the way along a new line of progress by helping to bring teacher and pupil, under favorable conditions, into the presence of living nature out of doors, adding to the methods of the class room and the laboratory of biology those of observation, study, and instruction in the field.

The art of the fish-culturist is to our waters what the art of agriculture is to our tillable lands. Each was in the beginning purely empirical, resting on a small store of common knowledge gained by the crude experience of the uneducated and the untrained. Agriculture has now been largely placed on a scientific foundation, and vigorous efforts are making all over the civilized world to extend, to deepen, and to render more exact in every direction our acquaintance with the sciences which underlie the practice of this oldest of the arts. The development of fish-culture has, however, lingered far behind that of its companion subject, compared with which it is indeed still in the stage of barbarism. We treat the product of our natural waters with a degree of intelligence and skill scarcely above that which the Indian exhibited in his rude attempts at agriculture before the time of Columbus. Our Biological Station was founded in part with the hope of helping to do for fish-culture what our forty or more agricultural experiment stations are now doing for the agriculture of the United States.

To accomplish these various ends, it was necessary that a subject should be chosen and that a location should be found offering a suitable field for scientific research of a kind to reward the skilled investigator with results of scientific value, and that these results should also interest a larger public than that which is prepared to appreciate and to utilize purely technical work. It was essential that this location should be

readily accessible from the University, and that it should be attractive, comfortable, and convenient as a center of operations for visiting investigators and for general and elementary students of our field biology. The purposed relation to fish-culture of course required that it should be on or near some lake or stream, or, better still, on some system of waters including both lakes and streams in large variety and in close proximity. After a careful study of the University environment, I selected in 1894 the Illinois River and its dependent waters as our general field, and the vicinity of Havana, in Mason county, as the principal seat of our operations. (See map, Plate I.) Our two years' experience here has served only to confirm our first impression, that a very suitable and, indeed, highly fortunate selection had been made.

LOCATION AND FIELD OF OPERATIONS.

The Illinois River near Havana (Plate VIII.) has a maximum width of about 500 feet at the lowest stage of water, and a maximum depth at that stage of approximately ten feet. For a distance of about five miles, at the town and above and below, it runs along the foot of a steep sandy bank or bluff, ranging from forty to eighty feet in height (Plates II., XI., and XII.), itself the edge of an extensive deposit of glacial sand extending with little interruption some seventy miles along the eastern side of the river, and perhaps a dozen or fifteen miles in width from east to west. The bottom of this bed of sand is not anywhere exposed near Havana and has not been reached, so far as I have learned, by any borings in that vicinity. From the foot of the bluff, at or near the water's edge, is a more or less general oozing of clear cold water sometimes flowing forth in springs of considerable size and sometimes forming small marshy tracts between the river and the bluff.

The opposite or western bank of the river here (Plate X.) is of black earth, the border of an alluvial bottom three or four miles wide, in which are several ponds and lakes and through which Spoon River (Plate XVIII.) winds its way, entering the Illinois nearly opposite the town. At the upper end of this five-mile stretch the river leaves the sandy bluff, having thence alluvial banks for some distance northward. The remnant of an old river bed continues upward, however, from this point

along the bluff in the form of a narrow bay one and a half miles in length, the so-called Quiver Lake (Plate XIII.), open to the river below, and receiving Quiver Creek at its upper end. This creek (Plate XVII.), largely formed by the drainage of a sandy tract to the east and north, empties into the broad and shallow head of the lake through a muddy and weedy flat. Quiver Lake, like the river below, has a sandy bank and margin on the east, and a mud bank on the west. The natural drainage of the sand escapes in large quantities along the eastern side of this lake, keeping the shore constantly saturated with cold water, to a greater or less width according to the level of the lake, and modifying greatly, when the river is low, the character of the waters of the lake itself. A broad bay of this Quiver Lake extending to the west from near its middle, forms what is known as Dogfish Lake (Plate XIV.), with shores of black alluvial earth all around.

The other waters of the vicinity included in the system of Station operations are Thompson's Lake (Plate XVI.), a shallow body of water about five miles long by one mile wide, lying in the bottoms near the western bluff; Flag Lake (Plate XV.), a shallow muddy pond or, more correctly, a marsh, about three miles in length, largely overgrown in summer with the club-rush, water-lily, and arrow-head; and Phelps Lake, a small pond of dead water, three fourths of a mile in length, with almost no vegetation, in the midst of a densely wooded bottom-land.

The field headquarters of the Station party, the summer location of the laboratory boat, was at the foot of Quiver Lake, against the sandy eastern bank (Plate II.). The top of the bluff is here wooded at the edge and for a variable distance back with oak and hickory and ash and other common hard-wood upland trees. Cottonwoods, walnuts, locusts, coffee-trees, elms, and pecans of a considerable size, extending in a rather ragged line, offer a very welcome shade at the foot of the bluff at about high-water mark. An abundant supply of very pure and delightfully cool water is easily reached everywhere, either in running springs or by driving down an iron pipe for a few feet in the sand and screwing on a common cistern pump.

The occasional narrow swampy flats along the eastern bank of Quiver Lake and beside the river between that lake

and the town, are usually tangled thickets of underbrush and swamp-land trees, which at certain seasons of the year are gay with multitudes of flowers and vocal with the songs of a great variety of birds. The general aspect of the flora of the sandy bluffs is quite unusual for Illinois, many plants occurring there abundantly which are rarely seen in ordinary situations. The bottom-lands become covered in late summer and autumn with an immense growth of composite plants, setting the intervals and recesses of the forest ablaze with yellows, purples, and reds, and loading the air with the heavy odor of the upland Eupatorium.

This forest itself, beginning at the water's edge with a billowy belt of pale green willows (Plates IX. and XIII.), is an untamed tract of primitive wilderness, differing from that through which the Indian hunted his prey only by the absence of the small percentage of its growth which had a commercial value. Subject to periodical overflow, it has not even been fenced. Elms and pecans and sycamores tower overhead or slowly moulder where they fall, and vines and creepers clamber over the underbrush in a growth like that of a semi-tropical jungle (Plate XX.). The shallow lakes and swamps are glorious in their season with the American lotus and the white water-lily, the former sometimes growing in tracts of a hundred acres or more, over which its gigantic peltate leaves, borne on tall slender stems, flash in the sun as they bend to the summer wind. In July and August many of the lakes are nearly filled with submerged vegetation, and in the latter part of the season a film of the duckweeds forms along the shore and floats in large patches down the sluggish current of the stream. Water-fowl abound at the period of their migrations, and fish lie on the shallows, basking in the summer sun in numbers such that dozens may be seen at a time as one floats along in a boat.

The microscopic life of the water is equally varied and abundant, a measurement of the quantity present in a cubic meter of water showing that with a single reported exception* it is at certain times far in excess of the amount recorded for any other situation in the world. The variety of species present is equally remarkable. The list of those occurring in a single cubic meter of water from the river at Havana in the month of

* Dobersdorfer See, Holstein.

July contains about twice as many as any of the lists of those found at the same time in the lakes of northern Germany or in our own Great Lakes.

The bluff beyond the bottoms to the west is higher than that on the east, and usually of a very different character. Strata of carboniferous rock, sometimes containing veins of coal, outcrop locally near its base, while the higher slopes are formed of yellowish clays, ditched and gullied by the rain, with occasional small streams flowing through gorge-like valleys from the level uplands of the country farther west.

The description thus far given applies to the lower stages of water only. When the river is at flood the entire bottom-land from bluff to bluff is often wholly under water, lakes, streams, and marshes being then confounded in one unbroken sheet from three to five or six miles across (Plate XIX.). As the river level varies some eighteen feet between high and low water mark, it may reach in its deepest part a depth of nearly thirty feet. These periods of inundation are very commonly two in a year, one beginning in late winter or spring with the melting of the snows, and the other coming most frequently in June or July, as a consequence of the early summer rains. The rise at either or both these periods is occasionally so small that no very marked effect on the biology of the river is produced. It was, in fact, fortunate for our operations that the first two years of our occupancy of the Station were marked by this comparative uniformity in the river level. Observations and collections made at this time have given us a fairly steady biological base line, by comparison with which variations in other years may be detected, due to extensive overflow and subsequent recession of the waters.

The plan and purpose of our work was such as to make it necessary that we should choose a number of regular stations—called substations in our reports—at which collections should be made and observations placed on record at regular periods for the entire year, and one year after another. These substations, thirteen in number, were chosen to represent the greatest variety of biological situations which the territory within our reach would permit (see map, Plate I.). They have been sufficiently characterized in the introductory part to a report by the Station Entomologist, Mr. C. A. Hart, on the entomology of the

Illinois River and adjacent waters, published in the Bulletin of the State Laboratory of Natural History in 1895. It may be said in general that the substations chosen represent the springy bank and sandy margin of Quiver Lake and of the river itself in both swift and sluggish water, the opposite mud bank of river and lake, shallow mud flats overgrown with water weeds, the bed of river and lake in the deepest water occurring, and three forms of bottom-land lakes, together with a fourth occasionally visited. Thompson's Lake gives us a permanent body of water of some little depth, always opening into the river, even at its lowest stage, but contrasting with Quiver Lake in the fact that this opening is long and tortuous, while in the latter it is half as broad as the lake itself. Matanzas Lake, on the eastern side of the river, but below the town, is substantially intermediate in character between these two. Like Quiver Lake, it has a high, wooded, sandy eastern shore and low forest-covered mud banks on the west, with an inlet at the head, which is, however, smaller than Quiver Creek. The flow of spring water from the sand is much more abundant. Like Thompson's Lake, its outlet is narrow, but it is very short. This lake commonly has more vegetation than Thompson's and less than Quiver Lake. In Flag Lake we have little more than a fairly permanent swamp, subject, indeed, in extraordinary years to be dried out completely, but overflowed again from the river at every slight rise. Phelps Lake, on the other hand, serves as an example of the highly variable conditions prevailing in a pool filled up at every general overflow, but isolated on the retreat of the waters, and drying out entirely in the very driest years.

ESSENTIAL OBJECTS.

It is the general object of our Biological Station to study the forms of life, both animal and vegetable, in all of their stages, of a great river system, as represented in carefully selected typical localities. This study must include their distinguishing characters; their classification and variations; their local and general distribution and abundance; their behavior, characteristics, and life histories; their mutual relationships and interactions as living associates; and the interactions likewise between them and the inanimate forms of matter and of energy in the midst of which they live. We are, in short, to do what

is possible to us to unravel and to elucidate in general and in detail the system of aquatic life in a considerable district of interior North America.

So vast a subject must of course be intelligently divided and studied part by part, in some systematic order, to avoid a dissipation of effort and to insure the speedy attainment of some definite and tangible results. Its most obvious divisions are the systematic, the biographical, and the œcological; and this is the order, broadly speaking, in which the general investigation must be carried on. Both systematic and biographical biology have a high independent value in our scheme, but both are with us chiefly means to the remoter end of a study of the interactions of associate aquatic organisms, and of their relations to nature at large. It is thus the œcological idea which is to lead in the organization and development of our work. A systematic survey of the biological assemblage is a necessary preliminary step, and the tracing of life histories and the recognition and description of immature stages is a scarcely less essential prerequisite; for without the knowledge which these studies are to give us, it would be obviously impossible to make any comprehensive study of variations, distribution, and œcological relationships.

The œcology of the Illinois River is greatly complicated, and the difficulty of its study intensified, by certain highly and irregularly variable elements of the environment. Apart from those secular and more or less inconstant features of climate and weather which must be taken into account wherever such studies are prosecuted, we often have here the evidently very large and highly intricate reactions produced by periodic variations in the river level, and the consequent enormous extensions and corresponding diminutions of the mass of the waters and of the area covered by them. Fortunately for the possibilities of success in so difficult a field, progress in it does not require that the entire system of life should be studied as a unit at first. Special problems may be selected, of a kind to be brought easily within the available time and the capacities of the individual investigator, which, being worked out one by one, may be later brought together as contributions to a solution of the larger problems involved. While it is true, for example, that nothing in or about the waters studied which in any notable way affects

any of the great groups of the system can be wholly a matter of indifference to the scientific student of fish-culture, the interests of every species being more or less intimately bound up with the interests of every other, yet at least provisional conclusions of considerable practical value may be reached, with regard to this, that, or the other kind of fish or with regard to fishes at large, long before the entire system of interactions and relationships is fully understood. It is not necessary that we should know the food of every species of fish in the locality before we can generalize profitably the food relations of any one, although inference from such provisional generalizations must always be held subject to modification as our knowledge of related matters grows. A similar remark may be made with respect to such purely scientific matters as the limits and causes of variation, a very useful knowledge of which may be acquired without a full and final theory of variation in general.

In actual practice it has been found that our work may best be opened up by comprehensive studies of the classification such as will give us a critical knowledge of all the forms occurring in our field and access to the published literature of each, and by parallel or slightly subsequent studies of their habits, life histories, and local distribution and abundance.

GENERAL METHODS.

The principal methods of the biological station are those of field and laboratory observation and record, collection, preservation, qualitative and quantitative determination, description, illustration, generalization, experiment, induction, and report.

By close and persevering observation in the field, we learn much of the actions, habits, and haunts of animals, of the special conditions under which they live, and of many similar matters which cannot possibly be learned in any other way; and not a little of this knowledge is necessary to an intelligent treatment of both general and special problems in biology.

The acute, persevering, sympathetic observer of living nature—the "old-fashioned naturalist," in short—is best to be understood as a "synthetic type," all of whose best qualities should be not only preserved but intensified among his variously differentiated progeny. If I may generalize my own experience, I must say that it is extraordinarily difficult at the present time

to find for this work the trained and intelligent naturalist, habituated to the methods of the close observer, whose eye nothing escapes, but whose mind rapidly and skilfully sifts the miscellaneous offerings of his senses, holding the significant and suggestive and letting slip the trivial and the unessential. There seem to be among our younger college men ten practical embryologists to one good observer. It is, in fact, the biological station, wisely and liberally managed, which is to restore to us what was best in the naturalist of the old school united to what is best in the laboratory student of the new.

On the other hand, the variety of uses which must now be made of preserved material in the course of our Station studies necessitates the frequent employment of the nicest methods of the histological laboratory, and a complete acquaintance, at least, with laboratory methods in general.

Definite and precise comparisons of different aquatic localities with respect to their biology have first been made possible in some considerable measure by the comparatively recent introduction of more or less exact quantitative methods for the collection and determination of the biological contents of the water. These, commonly known as plankton methods, enable us also to study the biological history of any locality to which they are fully applicable, by making it possible to bring into close comparison the organic contents of the water from day to day, from season to season, and from year to year. Unfortunately, these methods are not as yet capable of application to all aquatic forms in all situations, but have been used successfully only for the smaller plant and animal forms of the clear open water.

By using always identical apparatus in a perfectly uniform manner for the accumulation of microscopic and semi-microscopic objects in such waters and preserving the product by identical methods, it is possible to make and keep collections which may serve as a means to a precise comparison of the mass of organic life in the waters studied, or of the number of individuals representing any selected species.

In our own Station work these plankton operations have been carried forward from the beginning at all the substations where open water could be found in condition to permit the hauling of our plankton net, or, later, the use of the plankton pump. A large number of quantitative determinations of col-

lections so made have been worked out in a way to give the actual quantity of organic life in a cubic meter of water for each situation studied by this method, and enumerations of various forms have likewise been made under the microscope by methods such as to give us reliable data for a comparison of the various waters with reference to the number of such forms in a cubic meter of water. Approximately quantitative collections have likewise been made, wherever possible, in situations which do not permit the use of this plankton apparatus, but with results far less reliable, of course, because based mainly on personal estimates, and obtained by the use of less precise and exhaustive methods.

It seems not impossible that quantitative and numerical plankton work will be found to have a certain value as a ground of inference concerning the biological contents of water which cannot be searched by the plankton apparatus. In other words, definite, if general, relationships may be found to exist between the amount and composition of the plankton in the free and open water of a given lake or stream at any given time and the mass and variety of living forms contained in the marginal shallows or imbedded in the mud of the bottom.

Considerable modifications have been made at the Station since it opened, in the details of the quantitative method, often forced upon us by the peculiarities of the location and the special conditions under which our work was carried on, and interesting improvements in special apparatus have resulted from the effort to overcome our peculiar difficulties. A paper on our plankton methods and apparatus is now in course of preparation by the Superintendent of the Station, Dr. C. A. Kofoid, to whom this department of the work has been assigned.

As our work progresses and special problems are taken up for separate and continuous investigation, the experimental method will necessarily come prominently into use. The object of biological experimentation is the interpretation of nature, and, like all intelligent experimental work, it must be suggested and guided by observation and hypothesis. With us it is the œcological field in which experiment is especially called for. Given certain phenomena of local distribution, of relative abundance, of association, of habit, of variation, and the like, whose causes it is desirable to ascertain, it is incumbent upon

us, by a critical and exhaustive study of the environment, to find the materials for rational hypotheses as to such causes, and to test such hypotheses by experimental procedure. It is thus always the field observation, or the laboratory observation made under conditions which involve the least practicable departure from natural conditions actually existing, which must precede and suggest the experiment. The method and the general object of this work resemble thus more closely, on the whole, those of the agricultural experiment station—which is, indeed, a biological station under another name and devoted to a special end—than those of the laboratory of experimental physiology; and it is because ours is to be in the end and in its final objects a station for the solution, by experimental methods, of both special and general problems in the field of œcology that it was christened by its official board of control the Biological *Experiment* Station of the University.

EQUIPMENT.

The main features of our present equipment are the laboratory boat and its contents, the steam launch, a number of skiffs, and the apparatus and belongings of the Illinois State Laboratory of Natural History and of the biological departments of the University of Illinois, both of which are placed, without restriction, at the service of the Station force.

THE FLOATING LABORATORY.

Our ultimate objects do not limit us to any single field, but will eventually compel us to transfer at least a part of our operations to other points for purposes of comparison and contrast. Indeed, the Illinois River work is but a convenient point of departure for an investigation of the whole Mississippi River system. These facts have made necessary for us a movable construction of considerable size, carefully designed and thoroughly equipped for our work. Furthermore, the great changes of water level and the enormous expansion of the area covered at flood in the region over which we operate, would make a location on shore oftentimes extremely inconvenient as working quarters for our Station force. There is a great advantage also in a position in the very midst of our field, where contact with the objects of our interest must be almost con-

tinuous. It seemed, consequently, clear that a house-boat or so-called cabin-boat of special construction, furnished as a biological laboratory, but with an equipment for minor experiments also, would meet our needs far more precisely than a building on shore.

This laboratory boat (Plate III.), launched in April, 1896, was built at Havana from plans drawn up under my direction by Messrs. Gunn and McLane, of the architectural department or the University. A strongly built hull of Washington fir supports a deck 20×60 feet, upon which is a cabin 16×56 feet. In building the hull, extraordinary pains were taken to obtain a steady construction. A three-inch solid bulkhead was run lengthwise through the middle, and two keelsons divide the space between this central bulkhead and the gunwales. Lateral strength was given by four series of diagonal braces, set as shown in Plate VI., and placed every two feet, and by three hog-chains run from the bottom of each gunwale over the middle bulkhead. As a consequence, the floor of the boat proved to be remarkably steady, no tremor being noticeable in the use of the higher powers of the microscope on minute objects suspended in fluids. The interior of the hull is ventilated by means of four hatchways with movable covers, two at each end of the deck.

The cabin (Plates IV., V., and VI.) has six large windows on each side, made freely movable for ventilation, and also transom ventilators above the windows. The roof is penetrated by four large ventilators, and walls and roof are made double, as a protection against the heat, by ceiling with Georgia pine. By virtue of these arrangements the laboratory rooms were remarkably comfortable during even the hottest weather of the year.

The interior of the cabin is divided into four rooms: an office and library at one end 11 feet and 6 inches by 16 feet, occupied by the Station staff; a main laboratory 29 by 16 feet, primarily for visiting students and for the experimental equipment; a kitchen 8 feet and 8 inches by 12 feet, with gasoline stove and other cook's equipment, in which mid-day meals can be prepared for the Station force; and a small closet or store-room adjacent to the kitchen. The main laboratory is provided with tables, two to each window, and with shelving against the

walls for books, note-boxes, specimens, etc., while down the center of the room is a sink-table 3×22 feet, covered with zinc and furnished with a water supply for numerous small aquaria. A long overhead zinc-lined tank is supplied by iron piping, with a screw end outside the boat to which the discharge pipe of a hand force-pump can be readily attached. Stopcocks and glass and rubber tubing make the necessary connections with the tanks and jars used for aquarium work, the overflow being carried off by drainage pipes which empty outside the hull. The space beneath the central table is enclosed with doors and provided with shelves for general storage.

The boat has no motive power but is intended to be towed from place to place as occasion requires. Our steam launch "Illini" (Plate XI.) proved, indeed, to have sufficient power to transport this boat under ordinary circumstances.

This launch, built by the Racine Boat Manufacturing Company, of Racine, Wisconsin, is 25 feet long by 6-foot beam and is licensed to carry seventeen persons. The machinery furnished with it was replaced during the summer by a compound engine of four and a half horse power, with keel condenser. Both boiler and engine were designed by Assistant Professor VanDervoort, of the University department of mechanical engineering, and the engine and the speed propeller were made under his direction at the University shops. The launch was not designed especially for speed, the distances to be covered in our work being usually very short. It gives us, however, a rate of about six miles per hour. It is entirely safe in all weathers to which it may be exposed in our situation—a point of special importance to us since our regular routine of field work must be carried out without reference to storm or temperature. Four skiffs of various sizes and a portable canvas boat complete the aquatic equipment.

The more peculiar items of the field and laboratory apparatus are the plankton equipment, the breeding-cages for the aquatic insects, and a specially constructed centrifugal machine for the rapid precipitation or condensation, in graduated tubes, of the product of quantitative collections. This last is a modification of the centrifuge used by physicians, the tubes and tube carriers being the same, but the mechanism being especially designed for us by Professor VanDervoort and made

under his supervision at the University shops. The plankton apparatus first used consisted of a peculiar conical net (Apstein pattern) made of No. 20 silk bolting cloth. This was hauled through the water obliquely from bottom to top, a distance of thirty meters, at a perfectly uniform rate, the movement being timed by seconds counted with watch in hand. The net was suspended to a carrier and drawn along a tightly stretched line, to which it was hung by means of pulleys, the various particulars of the arrangement being devised by Assistant Professor Smith, in charge of the plankton apparatus and the Station itself during the first year. In May, 1896, this plankton net was superseded by a hand force-pump (Plate VII.), selected after considerable investigation of various styles, of a size and weight to be conveniently managed in a large skiff. The feed pipe of this pump is long enough to reach the bottom in our deepest water and the discharge pipe delivers into a straining net suspended in the water from a float. To secure the contents of a vertical section, the further end of the feed pipe is sunk to the bottom and slowly raised to the surface, the pump being meanwhile worked by an assistant in a perfectly regular manner. Minor features of the apparatus and items of the procedure will be described in a special paper on our Station methods, now in course of preparation by the Station Superintendent.

For keeping insect larvæ under perfectly natural conditions but exposed to continual observation small cubical boxes were used, with two sides and the bottom of wood and the other two sides of wire gauze, and a cover of glass set in a wooden frame which overhangs the top of the case, fitting closely to the sides. These cases were placed around a large float in the lake or river in such a manner as to be kept about half full of water, which, of course, had free access through the wire gauze sides.

The laboratory boat was amply stocked with compound and dissecting microscopes and a supply of chemicals, glassware, and apparatus for the preservation of specimens and for microscopical technology. It was equipped for fifteen workers, in addition to the Station staff. The excellent working library of the State Laboratory of Natural History was freely drawn upon for everything needed in aid of the special work in progress at the time, and the library appropriation of the Laboratory was

also used as necessary to supply desiderata. This aquatic establishment was found in all respects so satisfactory and convenient, that rented rooms in the town, similarly furnished, were presently abandoned by the entire party, all preferring to work upon the boat.

ORGANIZATION AND STAFF.

The staff of the Biological Station is composed of the Director and certain assistants of the State Laboratory of Natural History, all of whom are appointed by the Trustees of the University of Illinois, and all except the Director upon his nomination. This officer is responsible for the organization, equipment, and general and financial administration of the Station, for the plan and objects of its operations, for the establishment and assignment of departments, for the main features of the papers and reports, and for the editorial supervision of the Station publications. The Superintendent, who is appointed as such officer although borne upon the list of the assistants of the State Laboratory, has immediate charge of the Station force and is responsible to the Director for the execution of its plan of operations. He is allowed a large latitude with regard to details, and in the absence of the Director all the workers at the Station are under his immediate orders.

From the establishment of the Station in April, 1894, until June 30, 1895, Mr. Frank Smith, at first Instructor and later Assistant Professor in the University department of zoölogy, served as Superintendent, devoting his time continuously to Station work until January 1, 1895. He had special personal charge of the quantitative collections—the so-called plankton work—during this period. He also began during the summer of 1894 a systematic study of the oligochæte worms of the Station and its vicinity, which he has continued to the present time, giving to this subject his vacations entire, and such time as is left him after the performance of his duties in his University department. He was assisted in his work from May to September, 1894, inclusive, by Mrs. Dora Smith, who served the Station as its microscopical technologist during that period. Beginning with July 1, 1895, the Station has been in charge of Dr. C. A. Kofoid as Superintendent with the planktology of the situation as his special department. He also acted as superin-

tendent of construction during the building of the laboratory boat. His entire time has been given to the Station work except for the teaching of one University class for one term, undertaken as an exchange of services with the zoölogical department.

The entomological work has been, since the commencement, in charge of Mr. C. A. Hart, Systematic Entomologist of the State Laboratory, assisted for two of the summer months of 1895 by Mr. Ernest B. Forbes. Mr. Hart's share in the regular routine of Station operations has been the making of the inshore and longshore collections at the various substations. In addition to his studies of the habits and life histories of aquatic insects, he has listed the Mollusca of the collections since September 8, 1894, and from that date to July 1, 1895, he was the sole continuous occupant of the Station, being responsible for the regular field work, carried on with the assistance of visiting parties from the State Laboratory, at Urbana.

Mr. Adolph Hempel was engaged without interruption upon a study of the Protozoa and Rotifera of the Station from its opening to June 1, 1896. At this time the condition of his eyes forbade further use of the microscope and he was placed in charge of the Station launch as its licensed engineer. He occupied the Station alone during the winter of 1895–96, keeping up, with such assistance as it was necessary to engage from time to time, the regular routine of collections and observations at the various substations.

Miss Lydia M. Hart, Artist of the State Laboratory, has devoted a large part of her time to drawings in illustration of the various papers prepared by the Station force. She was at Havana during about a month of 1895, the remainder of her work in this direction having been done at the State Laboratory.

Mr. Ernest B. Forbes has served during the vacation period of three seasons, the first as a general zoölogical assistant, the second as an assistant in the entomological field work, and the third in making a special study of the Cyclopidæ of the Station collections.

Periodical chemical analyses of various waters collected at the Station have been made, from the first opening, under the direction of Professor A. W. Palmer, of the chemical department of the University of Illinois. Mr. C. F. Hottes, Botanical

Assistant in the University, made several trips to the Station with Superintendent Smith during his regular visits in the winter of 1894–95, and both he and Professor T. J. Burrill, of the University department of botany, have made occasional collections of aquatic plants.

Mr. Miles Newberry, an experienced fisherman of Havana, has served the Station very efficiently from the beginning as a general assistant. He has been particularly serviceable as an aid in plankton work and has had immediate charge of the boat and of the aquatic equipment generally.

GENERAL EXHIBIT OF RESULTS.

Although the first report of results accomplished in a field so extensive and complicated as that occupied by our Biological Station must necessarily be largely an exhibit of work in progress, it seems possible to make a statement which shall give a comprehensive, if somewhat indefinite, idea of the outcome of operations thus far undertaken. This report may be made most conveniently under the heads of plankton operations, collections accumulated, entomological studies, molluscan collections and determinations, fresh-water worms, studies of Protozoa and Rotifera, chemical determinations, reports and publications, and the summer opening of the Station.

PLANKTON OPERATIONS.

The minute plant and animal life suspended in the waters of a river system, moving downwards with its current and washed to and fro by its waves, composes what is known to the modern biologist as the plankton of its waters. The Station operations in this field were primarily directed to a study of the amount of this plankton in the various locations selected, its seasonal and other periodic changes, its local and vertical distribution, its composition as to the species represented, and its relation in the general system of aquatic life. Our field of operations is a unique one, as yet practically untouched by the scientific investigator in so far as it is limited to a river system and its dependent waters.

The plankton substations in 1894 and 1895 were five in number: one in the river, a short distance above the foot of Quiver Lake; another in Quiver Lake itself; a third in Dogfish

Lake; a fourth in Thompson's Lake; and a fifth in Flag Lake, between Thompson's Lake and the river. To these were added in 1896 a substation at Phelps Lake—from which, indeed, a single quantitative collection had been made in 1894—and one in Spoon River a short distance above its mouth. From these various substations a thousand quantitative collections have been made since the Station opened; those from April, 1894, to June 30, 1895, by Professor Frank Smith or under his immediate direction, and those subsequent to that time by Dr. C. A. Kofoid. All these tows have of course been carefully preserved by methods such as to permit their quantitative comparison, and about three fourths of them have been quantitatively determined by Dr. Kofoid by methods of precise measurement. A considerable beginning has also been made in the enumeration of their contents by counting under the microscope.

Various modifications of plankton methods, elaborate tests of the apparatus used and of the methods of discussion current, and other items of improvement in the equipment and in the methods of planktology will be reported by Dr. Kofoid in a paper on this department of our work now nearly ready for the press. For certain general conclusions of considerable interest and of at least provisional value reference may be made to the same paper.

COLLECTIONS ACCUMULATED.

The total number of lots of specimens collected since the opening of the Station amounts to 6,628, besides 5,500 pinned insects. Of the former, 434 lots contain materials for a study of the food of animals, 300 of them being the contents of the stomachs of fishes; 270 are collections of vertebrates; 3,560 are preserved collections of invertebrate animals; 1,823 are towing-net collections; and 543 were collections of Rotifera and Protozoa, most of which were studied alive because incapable of satisfactory preservation. The entire number of collections, including under this head each object or lot of objects specially numbered and separately entered on our notes or in the accessions' catalogue of the Station, is thus nearly 10,000. Besides these, mention should be made of about 400 microscopical slides of serial sections of oligochæte worms made for Professor Smith in the course of his studies of that group.

LIST OF COLLECTIONS.

Shallow-water collections with Birge net	232
Qualitative collections with surface net	592
Quantitative collections with plankton apparatus	999
Protozoa and Rotifera, collections	543
Vermes, collections	490
Crustacea, collections	167
Arachnida, collections	235
Insecta (liquid collections)	2,245
Insecta (pinned specimens)	5,500
Mollusca, collections	388
Fishes, collections*	196
Amphibia, collections	59
Reptilia, collections	15
Food collections	434

ENTOMOLOGICAL STUDIES.

It has been thus far the primary object of the entomological studies made by Mr. Hart to make us fully acquainted with each species in all its stages as a preliminary to investigations along other lines. To this end extensive search has been made of all varieties of situation in the waters of the Station field, the species at each location being listed at each visit and collections being also made. The regular typical localities represented by the substations have been further searched at regular intervals for two years. About five hundred lists and illustrative collections have thus been accumulated. The biological observations and breeding-cage experiments made during this time are recorded on some seven hundred note slips.

The Hymenoptera and Lepidoptera and a large part of the Diptera have been worked up, and reported upon in a paper on the entomology of the Illinois River and adjacent waters, published as Article VI. of Vol. IV. of the Bulletin of the State Laboratory of Natural History. Since this publication much additional information concerning these groups has been acquired. Careful studies have been made on some of the smaller Diptera, on the water-beetles, and upon the Neuroptera, Thysanura, and Hydrachnidæ. The dragon-fly collections have been determined by Mr. J. C. Needham, formerly Instructor at Knox College, and by Mr. C. C. Adams, an assistant in the State Laboratory.

These entomological collections represent some 350 species of insects. Every effort has been made by breeding to identify eggs, larvæ, and pupæ of insects aquatic in any stage.

* About 2,000 specimens.

About 275 hitherto undescribed forms have thus been obtained and immature stages of about 225 species have been accurately identified.

MOLLUSCAN COLLECTIONS AND DETERMINATIONS.

The Station collections of mollusks, made mostly by Mr. Hart, contain about 11,000 specimens, 600 of which are clams (Unionidæ). All this material except that most recently brought in has been examined and determined by various American specialists. About eighty-five names of aquatic or semi-aquatic mollusks have thus been obtained, and their distribution and life history have received special attention. The Unionidæ have been studied with reference to characters derived from the entire animal, and much interesting information has been accumulated concerning their relationships, life histories, and parasites.

FRESH-WATER WORMS.

The greater part of the time of Professor Smith available for State Laboratory work has been devoted to a study of the oligochæte worms (earthworms and their allies) found in and about the Illinois River and other waters near Havana. Most of this work has necessarily been of a systematic character, although progress has been made along other lines. The importance of systematic work on this order is shown by the fact that with the exception of descriptions of two species published in Vol. III. of the Bulletin of the State Laboratory,* almost nothing has been known of the representatives of the group in the Mississippi Valley and but little, indeed, for all the eastern part of the United States.

Collections have been made from all the regular substations and at various places in the bottom-lands and along the shores of the river to a point two miles south of Havana. Many of the worms obtained were studied while living, and for further study about seventy bottles of specimens have been prepared and preserved in alcohol or formalin. For a successful study of most of these worms serial sections are indispensable, and thus far about 400 microscopical slides of such sections have been made and used.

*Art. IV. "On the Anatomy and Histology of a New Earthworm (*Diplocardia communis*), gen. et sp. nov., by H. Garman; and Art. VII., "On an American Earthworm of the Family Phreoryctidæ," by S. A. Forbes.

The work of identification is now nearly completed and probably nearly all of the different species occurring in the region are represented on our lists. Of the thirteen families of Oligochæta recognized by Beddard, nine are represented at Havana by thirty species belonging to sixteen genera. Less than one half of these species occur in Europe and the remainder, with few exceptions, are known only from the United States. Two new genera and at least seven new species have thus far been found by us.

Numerous experiments have been made in rearing naidiform worms and considerable new information has thus been acquired concerning their asexual reproduction.

Identification and description of the planarian worms of the Station collections has been kindly undertaken for us by Dr. W. M. Woodworth, of Harvard University, to whom all our material has been sent, much of it alive. The work on these collections has all been done and Dr. Woodworth's paper is nearly ready for publication.

STUDIES OF PROTOZOA AND ROTIFERA.

These minute animal forms of the Station fauna have been very patiently and thoroughly worked out from day to day for nearly two years by Mr. Adolph Hempel. As most of them could not be studied to advantage except in a living state, they have been determined as fast as collected. More than five hundred collections have thus been critically overhauled, and annotated lists of species and descriptions of new forms have been prepared and either published or made ready for publication in the Bulletin of the State Laboratory of Natural History. 102 species of Rotifera (three new) and 80 species of Protozoa (five new) have thus been listed from our situation by Mr. Hempel, and several others have been identified by Dr. Kofoid in the course of his studies of the plankton since Mr. Hempel's work was suspended as a consequence of injury to his eyes. Among these later acquisitions was one of the most remarkable and important rotifers known to science, a species of the genus *Trochosphæra*, which is famous in the annals of zoölogy for the light which it throws upon the zoölogical relationships of the Rotifera at large. This genus, founded on a species discovered by Professor Semper in 1872 in pools in the rice fields

of the Philippine Islands, is now further represented only by collections made at Brisbane, in Australia, and in the Yangtse-Kiang, in China, and by the Illinois River specimens observed by Dr. Kofoid in the summer of 1896.

CHEMICAL DETERMINATIONS.

In a thoroughgoing study of the œcological system of an aquatic situation, the chemical condition of the waters will necessarily be an important element, and the Station has consequently done what was possible to it in its present state to institute and encourage chemical studies of the waters from which its biological materials are collected. It is much to be desired that very frequent examinations should be made of the waters at all the typical substations with a view to tracing their chemical history at each of them throughout the day and under the changing conditions of season, stage of water, and the like. The gaseous contents of the waters are of special interest and importance to us, since they have probably most to do with the welfare of aquatic animals and plants. It has been impossible, however, during these first years to provide for more than the usual form of chemical examination of water as made for sanitary purposes, and even this would have been impracticable if the chemical department of the University of Illinois had not responded generously to my request that such analyses be undertaken.

Beginning in May, 1894, collections of water from the river and from various other points in the Station field have been made at regular intervals by Station assistants and shipped to the Chemical Laboratory of the University, where they have been examined either by Professor A. W. Palmer or by assistants working under his direction. Since the beginning of this work it has been merged in that of a Chemical Survey of the waters of the state established at the University in consequence of appropriations made by the state legislature to that end during the winter of 1895. One hundred and ninety-three analyses in all have now been completed, and a report setting forth the comparative results will be published during the current year.

REPORTS AND PUBLICATIONS.

The final major product of our Station work must be in the

form of published papers and reports, our material accumulations being of merely secondary interest and value and often of only temporary use. Necessarily, however, so soon after the organization of the work, it has not been possible to prepare and to publish papers of a sort adequately to represent the ideals of the Station management or to illustrate its final ends. Nevertheless, considerable contributions to science resulting from the investigations of the Station staff have already been printed or are now in press, and the preparation of manuscript is going actively forward in several departments. Quite in accordance with our original expectation, visiting students who have availed themselves of the facilities of the Station have prepared or are now preparing papers embodying the results of their investigations, credit for which must belong in part to our establishment, without which they would not have been written.

The principal contributions now in print are papers by Mr. Hart, Mr. Hempel, and Professor Smith. The first of these is an article by Mr. Hart on the entomology of the Illinois River and adjacent waters, filling one hundred and twenty-five pages of our Laboratory Bulletin and illustrated by fifteen half-tone plates. Professor Smith's additions to a knowledge of our oligochæte worms have appeared as two papers of the Laboratory Bulletin, describing four new species and a new genus of these animals, with a large amount of anatomical and histological detail. We have also printed an article by Mr. W. H. Ashmead, of the United States National Museum, on parasitic Hymenoptera bred from aquatic insects at Havana, containing descriptions of three new species. Four new species of Protozoa and three of Rotifera from Station situations have been described by Mr. Hempel in an article of the State Laboratory Bulletin, accompanied by five plates of illustrative figures.

We have now going through the press a third paper by Professor Smith, containing descriptions of a new genus and two new species of oligochæte worms from Havana, and of one new species from Florida, together with a description of the reproductive organs of *Pristina*, upon which subject nothing has heretofore been known. This article will be accompanied by four plates. A paper on the Ostracoda of North America, by Mr. R. W. Sharpe, a graduate student of the University, is also in press. This article has been made to include the product of a careful

examination of the collections made in this group from the opening of the Station to the midsummer of 1896. It is accompanied by ten plates.

Mr. Hempel's observations on the Protozoa and the Rotifera of the Station, accumulated during two years' continuous study, are in hand in the form of a completed manuscript, accompanied by thirty folded sheets setting forth in tabular form the distribution of the various species at each substation and also throughout the Station field for the different months of the year. This report was finished last September and will be printed without delay.

Dr. Kofoid has lately filed a report, which is about to go to press, on methods and apparatus in use in plankton work at the Station, accompanied by seven illustrative plates. He has in hand six other papers, which will doubtless be ready for publication before the end of the current fiscal year. These will include reports on the local distribution of the plankton in the Illinois River and its adjacent waters, on the sources of error in the plankton method, on the plankton of the river during the years 1894, 1895, and 1896, on the plankton of Phelps Lake,—a body of water of the ephemeral type,—an article on *Trochosphæra*, and one on *Cotylaspis insigne*—a remarkable parasite of the river clams.

Professor Smith has under way a general report on our oligochæte collections, to consist of about fifty pages of text with several plates. This report will contain a synoptic key and illustrated descriptions of species for use in identifying forms occurring in the State.

Mr. Hart, Station Entomologist, and Mr. J. G. Needham are working conjointly upon a report on the dragon-flies of the Station waters and their vicinity, and a list of the mollusks with biographical and œcological notes is in course of preparation by Mr. Hart.

Two senior students of the zoölogical department of the University, Mr. E. B. Forbes and Mr. F. W. Schacht, are engaged in thesis investigations, under the personal supervision of the Director of the Station, which will result in the preparation and publication of papers on entomostracan groups, one the Cyclopidæ, the other the Centropagidæ, of North America, including of course the Station collections.

I have myself undertaken to prepare, and have nearly finished, a comprehensive article on the Crustacea of the Biological Station field, with analytical synopses of all the groups and illustrative figures for the use of the student of our aquatic fauna.

A paper on the planarian worms found at Havana is now reported as practically ready for the press in the hands of Dr. W. M. Woodworth, of Harvard University. Articles in course of preparation by visiting investigators are "The Mycetozoa collected near Havana, Illinois, during the summer of 1896," by H. C. Beardslee, of University School, Cleveland, Ohio, and "Statistical Record of the Trematoda Parasitic in the Unionidæ," by Professor H. M. Kelly, of Cornell College, Iowa.

The excellent work done by the Station Artist, Miss Lydia M. Hart, in illustration of nearly all the papers of the foregoing list, is deserving of particular mention. One hundred and three drawings have been made by her of new or otherwise interesting animal forms, besides several drawings of pieces of apparatus and other features of the equipment.

General mention may also be made in this connection of the publication and widespread distribution of a preliminary report upon the Station* illustrated by seventeen plates of the situation and surroundings, and of a small illustrated pamphlet descriptive of the Station and its work, inviting advanced students and other competent investigators to share its privileges during the vacation months of 1896.

SUMMER OPENING OF THE STATION.

With the launching and equipment of the cabin-boat it first became possible for us to offer the facilities of the Station to students outside our own official group. Anticipating this opportunity, a pamphlet of twenty-four pages, containing twelve half-tone plates, was distributed in the fall of 1895, describing the Station and its surroundings, its equipment, its plan of operations, and its program for the season, and making the following offering:

"The establishment and recent equipment of the Biological Station of the University of Illinois will afford a unique opportunity to a limited number of competent students to become

*See Bien. Rep. Direc. Ill. State Lab. Nat. Hist., 1893-94, p. 14.

acquainted with the plant and animal forms and with the system of life of a continental river and its dependent waters, and with comprehensive methods and modern apparatus of investigation in aquatic biology. This opportunity, it is believed, will be valued not only by interior students who would like to enlarge their personal knowledge of the aquatic life of their own territory, but also by investigators of experience in other fields who may wish to extend their studies, for the sake of comparison, into a department of American biology hitherto practically unexplored.

"For these reasons, and notwithstanding the fact that this Station was established especially as a means of research by its own staff, it has been decided to open it for the months of June, July, and August to biological investigators and to students of some experience in zoölogical or botanical work. The present accommodations are sufficient for only sixteen persons additional to the Station force. Applications for admission must consequently be made in advance and at as early a day as practicable, with precise specification of the period for which the applicant wishes to occupy a table in the Station laboratory.

* * * * * * * *

"Applications for admission to the Station will be entertained this first year only from independent investigators and from students of biology who have had sufficient experience to render systematic instruction and continuous supervision unnecessary. Other things being equal, instructors in biological science in colleges and public high schools will be given the preference.

"Tables on the laboratory boat or in the rooms on shore, and other general laboratory facilities, will be provided for those whose applications are accepted; ordinary microscopic reagents will be supplied; and access will be given to the biological library of the Station. Books will also be loaned, as needed, from the library of the State Laboratory of Natural History and from that of the University of Illinois. Occupants of the laboratory will be expected to furnish their own microscopes or to pay a small fee for the use of those of the University. They are advised to bring also any collecting apparatus in their possession, as the laboratory equipment may

otherwise be insufficient for all wishing to use it. Students must furnish their own alcohol for private collections, and especially expensive reagents—such as osmic acid or platinum-chloride.

"Although the Station is established and maintained primarily for a study of life histories, interactions of organisms, and reactions with the environment, no restriction will be placed upon the lines of zoölogical or botanical work to be pursued by those in attendance. In making application, however, the candidate should describe the nature of the study he wishes to pursue, and should also indicate the kind and amount of preparation for such work he may already have had. Applications will not, as a rule, be considered later than a fortnight previous to the time at which a table is desired, and no formal permission will be given for a stay of less than two weeks. Within these limitations visitors may come and go at any time within the months of June, July, and August.

"Reports on the Protozoa, rotifers, oligochæte worms, Cladocera, and insects of the Station, and perhaps on one or two other groups also, will be in print by the 1st of June, and will be furnished free of charge to those desiring to make studies in these groups.* These papers will contain analytical keys, descriptions of species, genera, etc., or references to descriptive literature accessible at the Station, together with much biological and œcological detail.

"While no provision is made for formal instruction, it is expected that the membership of the Station will be organized as a biological club to hold stated meetings for conference, discussion, and occasional lectures by the Station force or by visiting specialists.

"An incidental fee of $5 a month will be charged to each participant."

The privileges thus tendered were finally accepted by seventeen persons, who were in attendance during the summer for periods ranging from three to ten weeks. Although the number of tables available for outside use was only fifteen, not all of this group were present at a time, and the floating laboratory afforded sufficient accommodations for all who came. The

*It proved impossible to carry out the intention expressed in this paragraph, but the unlimited use of the library facilities of the State Laboratory of Natural History made fully good to visitors the substance of this offering.

states and institutions represented and the subjects to which special attention was given are shown by the following list:

C. C. Adams, B. S., Assistant in Biology, Wesleyan University, Bloomington, Illinois. Dragon-flies.

H. C. Beardslee, A. B., Instructor in Science, University School, Cleveland, Ohio. Fleshy fungi, Myxomycetes, and aquatic flora.

Miss L. L. Conover, B. S., Teacher of Botany, High School, Detroit, Michigan. Algæ and Myxomycetes.

Charles Fordyce, Principal of the Normal Department, Biology, Nebraska Wesleyan University, University Place, Nebraska. Fresh-water Algæ and general biology.

H. A. Fraser, B. S., Teacher of Biology, High School, Joliet, Illinois. Fresh-water sponges and general biology.

W. K. Hill, A. B., Superintendent of Schools, Carthage, Illinois. Fresh-water Algæ.

G. W. Horton, Superintendent of Schools, Dwight, Illinois. Rhizopoda and general biology.

H. M. Kelly, A. M., Professor of Biology, Cornell College, Mt. Vernon, Iowa. Trematoda parasitic in clams.

J. G. Needham, M. S., Instructor in Zoölogy, Knox College, Galesburg, Illinois. Life histories of dragon-flies.

C. S. Oglevee, B. S., Instructor in Zoölogy and Botany, Lincoln University, Lincoln, Illinois. Protozoa and general biology.

C. E. Phillips, Millington, Illinois. Student at Eureka College, Eureka, Illinois. General biology.

Mrs. W. S. Pierce, Teacher of Science, High School, Havana, Illinois. General biology.

Maurice Ricker, B. S., Teacher of Chemistry and Biology, High School, Burlington, Iowa. Hydrachnidæ and general biology.

L. S. Ross, M. S., Professor of Biology and Geology, Drake University, Des Moines, Iowa. Cladocera of Iowa and Manitoba.

F. W. Schacht (U. of I., '97), Moline, Illinois. The Centropagidæ of the locality in connection with thesis investigation.

R. W. Sharpe, B. S., Teacher of Biology, High School, Danville, Illinois. Ostracoda.

C. A. Whiting, Sc. D., Professor of Biology, University of Utah, Salt Lake City, Utah. General biology.

FINANCIAL RESOURCES AND EXPENDITURES.

The entire sum available for the equipment of the Station and its maintenance for three years and three months has been $10,300, $1,800 of which was appropriated by the Trustees of the University March 13, 1894, for the commencement of the work, and the remainder of which was derived from legislative appropriation made in June, 1895. Two thousand five hundred dollars of this latter appropriation was for building and equipment and $6,000 for running expenses for two years. The equipment fund has been expended in the purchase and modification of the Station launch "Illini;" in building, furnishing, and equipping the floating laboratory; and in providing various minor items of apparatus and furniture.

The floating laboratory or cabin-boat cost $1,573 furnished and equipped, the contract price for construction being $1,255. Five thousand five hundred and six dollars had been expended September 30, 1896, on account of salaries and general expenses of the Station, a balance of $1,394 remaining in hand to the credit of the appropriation. The salaries for this period of thirty months have been $4,218—an average of about $140 per month—and the general expenses of the work have been $2,187—approximately $73 per month.

PRESENT NEEDS AND FUTURE DEVELOPMENT.

The principal present needs of the work, apart from a fund sufficient for its maintenance on existing lines, are (1) more elaborate provision for chemical investigations, (2) a salary fund sufficient to enable me to add an experienced botanist to our present staff, (3) a site of three or four acres near the foot of Quiver Lake, and (4) provision for two principal buildings on shore and for a small system of permanent ponds with a pumping equipment for their maintenance.

The necessary chemical work will undoubtedly be provided for by the Chemical Survey of the waters of the state if the funds available for that survey are made sufficient to enable the University chemists to meet our wishes in this respect. As already said under another head in this report, chemical analyses are a matter of the first importance to the whole investigation we have undertaken. They will have a very great incidental value also outside our own field because of their

bearing upon questions of public health as affected by pollution of the waters of the Illinois River by sewage and other waste from the towns above, and ultimately from Chicago by way of the drainage canal.

A knowledge of the plant life of the river is scarcely second in importance to that of its animal life; a fact which has been evident to me from the beginning, but which, nevertheless, I have been compelled largely to ignore because of lack of funds to provide for continuous botanical investigation. Several competent zoölogists were already in our employ as assistants in the State Laboratory of Natural History, and zoölogical investigation could consequently be provided for with little difficulty and at a relatively small expense. Furthermore, the smaller animal forms—the rotifers and the Protozoa—can be successfully studied as a whole only in the living state, while microscopic plants are capable of preservation in condition to make their subsequent determination practicable Our plant collections can consequently still be worked up by a botanist having an expert knowledge of aquatic forms. It is very much to be desired that another year may not be allowed to pass without provision for this indispensable part of our general subject, without which, indeed, final conclusions concerning the œcology and economics of our aquatic biology cannot possibly be reached.

The efficiency of our corps of workers and the quantity of the results of their work would be very greatly increased if provision were made for their continuous maintenance on Quiver Lake. Our daily trips to and from the town proved very wasteful of time and opportunity, and have added greatly to the expense of running the Station launch. Furthermore, notwithstanding the great usefulness of our floating laboratory, it is in some respects insufficient for the more advanced stages of our work, and should be supplemented by a laboratory building in the immediate neighborhood. Experimental researches will presently require a larger equipment than that now at our disposal in the jars and small aquaria to which we are at present confined. Finally, if the Station is to be utilized to the fullest extent as a means of instruction to teachers in the public schools, permanent provision for this work must certainly be made.

These various needs can be met by the purchase of a small tract of land now lying practically waste, by the erection of a small building on the bank of Quiver Lake which shall combine additional facilities for laboratory investigation with living quarters for the Station staff, by the excavation of ponds on the Station grounds and the construction of a water tank and pump, and by the building of a large pavilion, with some connected rooms, for midsummer work by visiting students.

Concerning the immediate future of the work, I beg to say that it is my present wish and intention, if the Station is maintained on a scale and under conditions to make it possible, to extend its work especially along three principal lines. The preliminary systematic survey having been now largely completed, I hope next to select specific problems for solution by experimental methods, working towards definite œcological results of scientific value. Studies of the lower forms of aquatic life in our situation are now so far advanced as to make it profitable to bring into our scheme of regular operations the fishes of these waters. A particularly thorough, continuous, and comprehensive study of them should be made from various points of view, in the hope especially of helping the fish-culturist to more intelligent methods and to more certain and permanent results.

Although the Station was founded primarily for investigation and its expenditures up to the present time have all been made directly to that end, it is very apparent that it has a highly important work to perform in the interests of public education. I hope to occupy fully and at once this broad field of usefulness which now lies so plainly open before us, not only by continuing and enlarging our offerings to advanced students and to investigating naturalists, but especially by providing all needed facilities and instruction in field biology and in special pedagogical methods to present and prospective teachers of the natural history subjects in all grades of the public school. As a first step to this object, I have already submitted to you a plan for a summer school of field biology to be opened during the vacation season of next year. This work should, I do not doubt, become a permanent and prominent feature of the Station operations.

I ought not to close this general review and presentation of the affairs of the Biological Station without calling your atten-

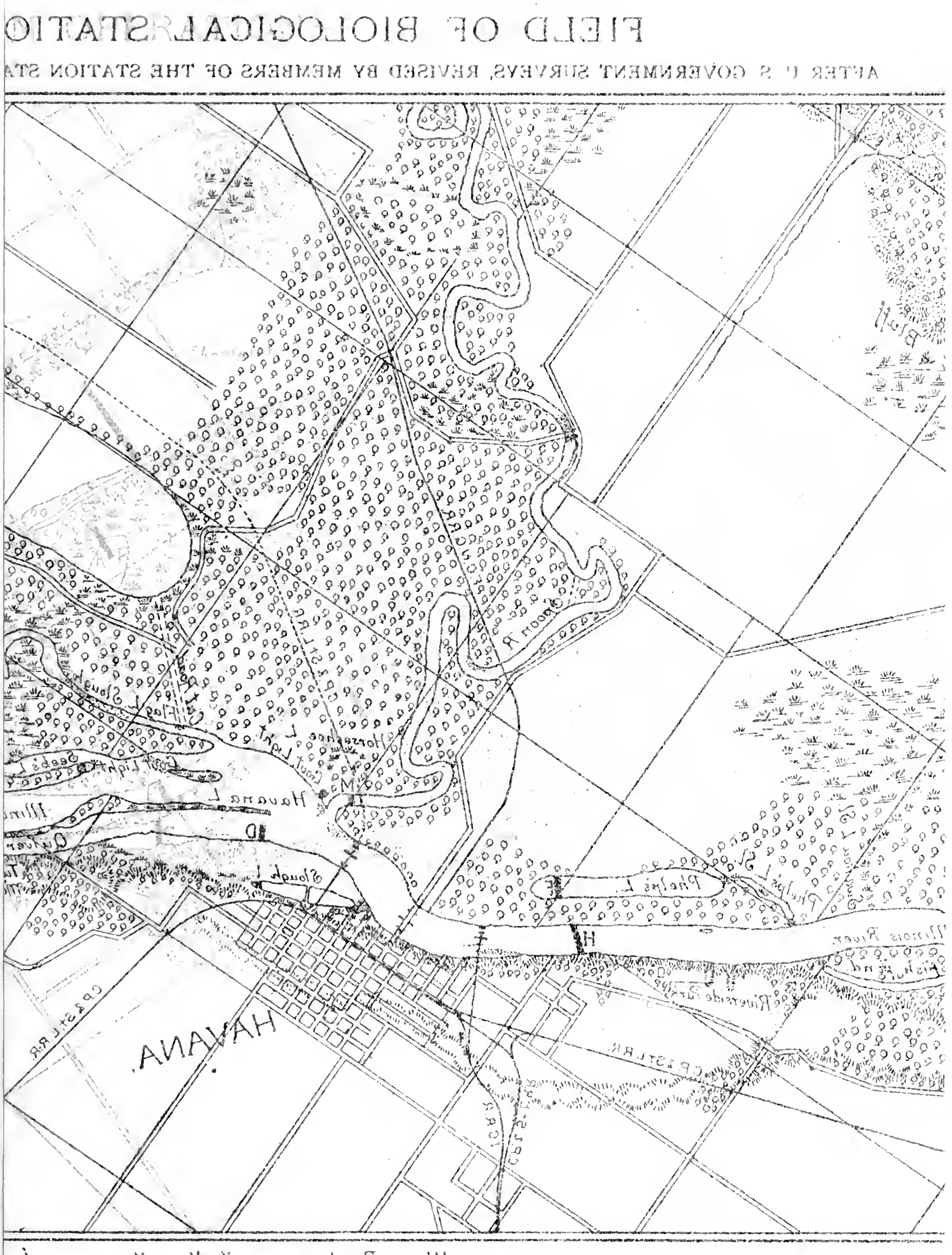
tion to the cordial and appreciative manner in which our enterprise has been received by expert judges of high rank in this country and abroad. Important articles on its work have appeared in several of the leading scientific journals of Europe and America, and our official correspondence also contains many expressions of warm interest in our success from eminent men in various parts of the world.

It gives me further pleasure to express to you my high appreciation of the capable, energetic, and successful work of my associates on the Station staff. Neither the broiling heat of the July sun nor the midwinter's cold have been able to interrupt or even to delay the regular progress of the very laborious and exacting routine of their operations; and the steady strain of long months of confining work at the microscope has been taken by them with the patient enthusiasm of the trained investigator at work in a fruitful field. The contagion of the example of this little group of indefatigable naturalists is clearly affecting the life of related departments of the University, and it must in time make itself sensibly felt throughout the state and the country in the advancement of biological science and in the improvement of our methods of biological instruction.

Respectfully submitted.

S. A. Forbes, *Director.*

November 30, 1896.


FIELD OF BIOLOGICAL STATIO
AFTER U. S. GOVERNMENT SURVEYS, REVISED BY MEMBERS OF THE STATION STA
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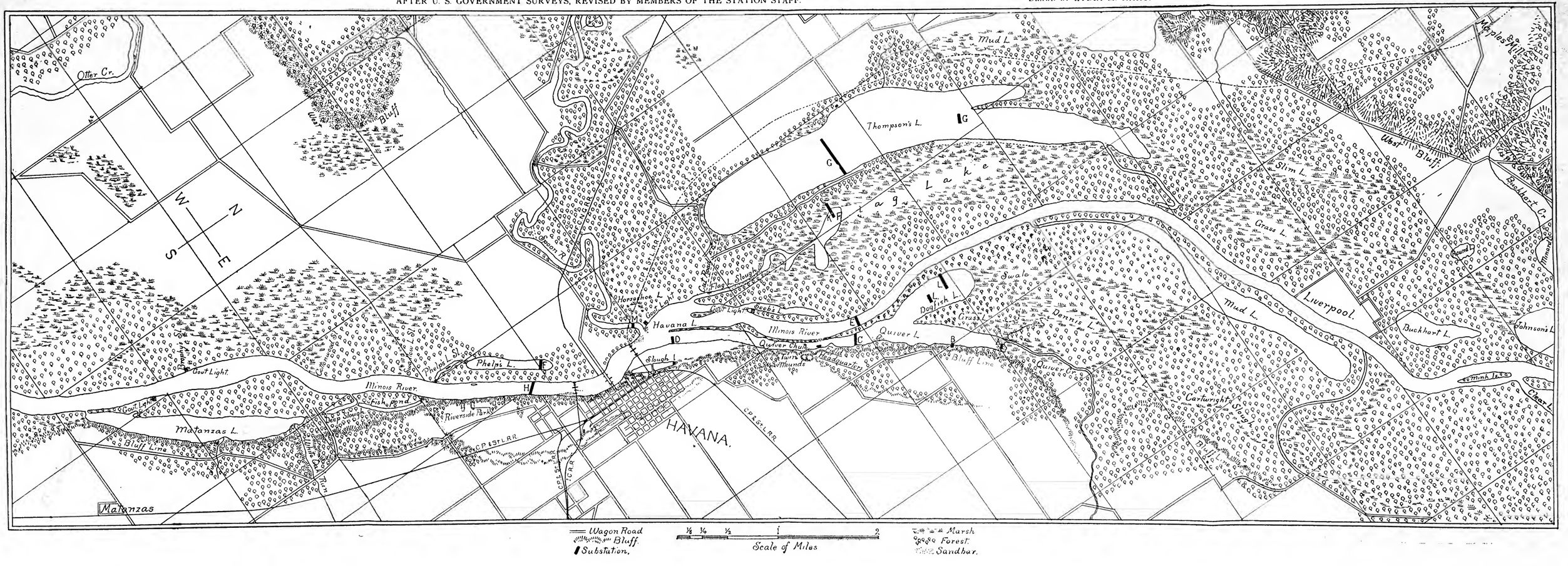
Havana L.
Phelps L.
Illinois River
Riverside Park
Wagon Road
Bluff
Substation
Scale of

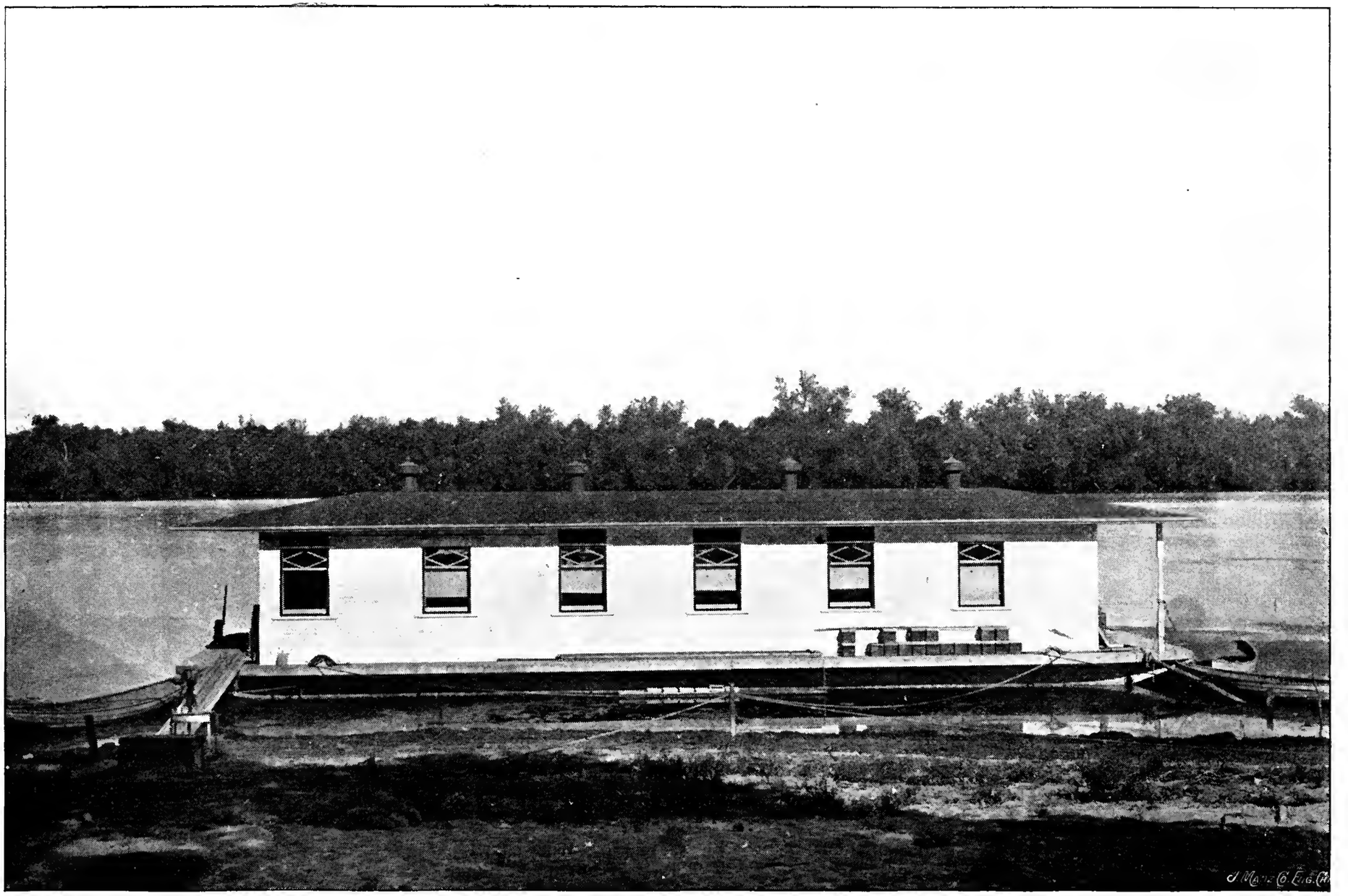
FIELD OF BIOLOGICAL STATION OPERATIONS. LOW WATER.

After U. S. Government Surveys, revised by members of the Station Staff.

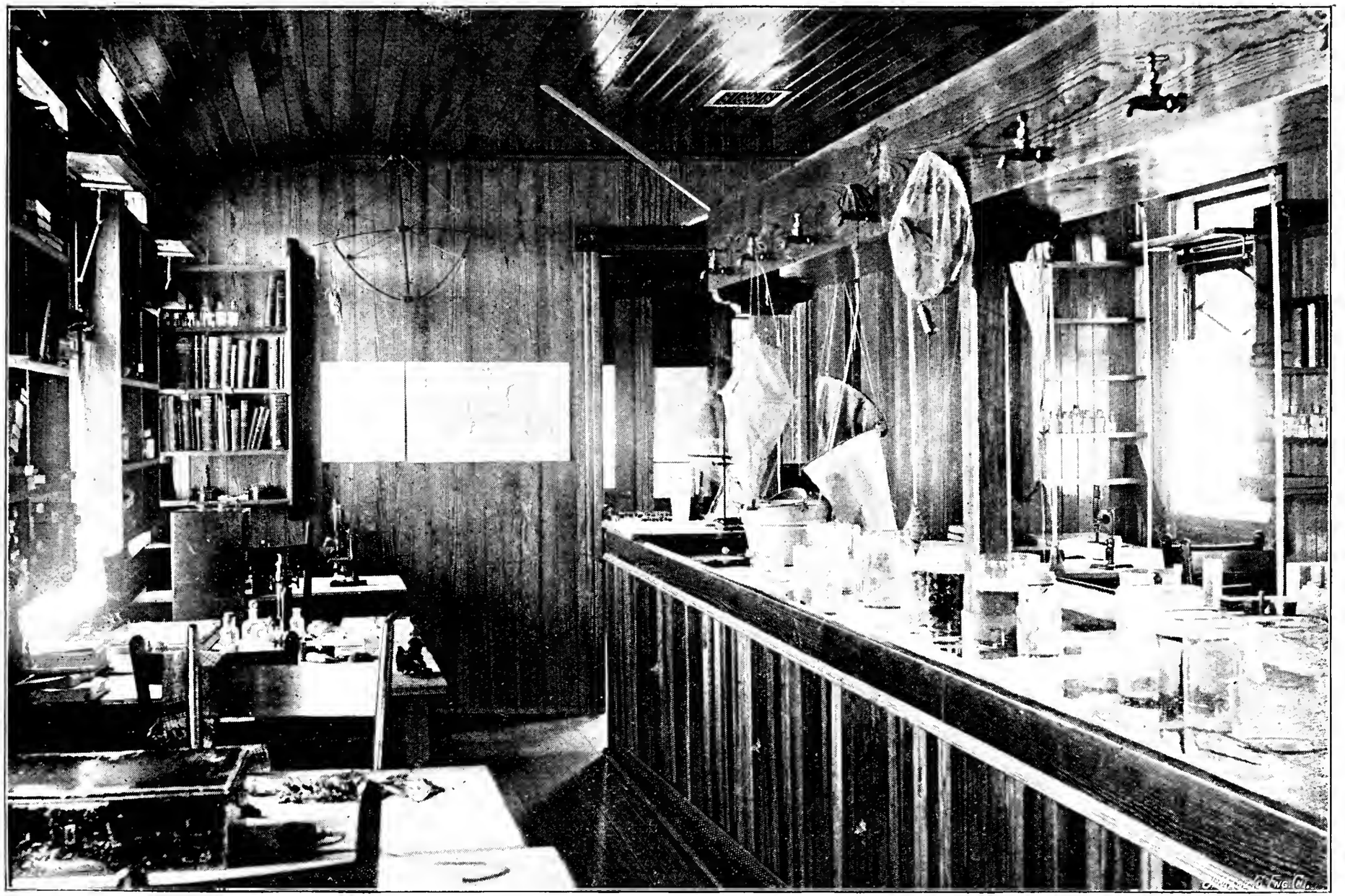
Drawn by Lydia M. Hart.



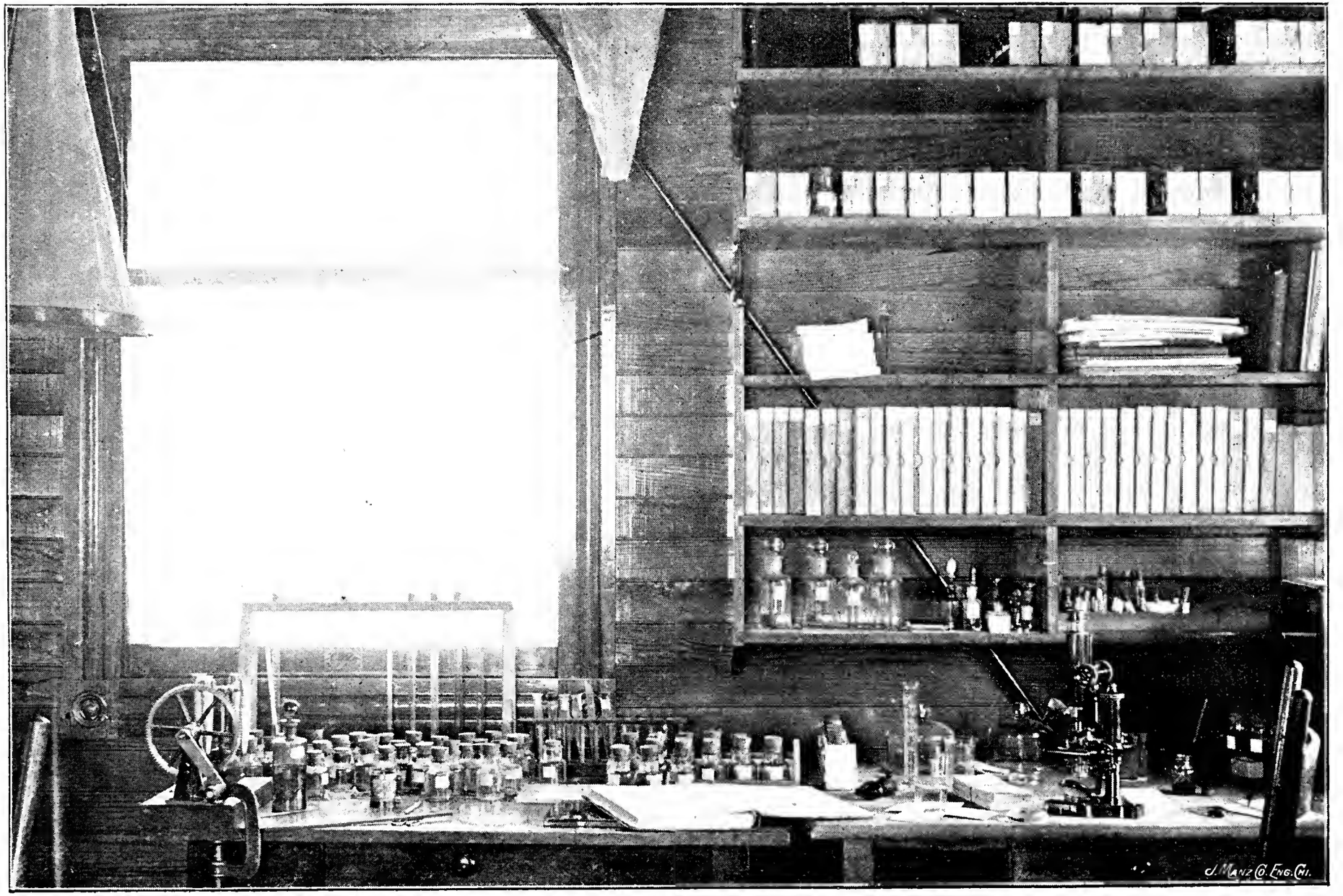
FIELD HEADQUARTERS, FOOT OF QUIVER LAKE.



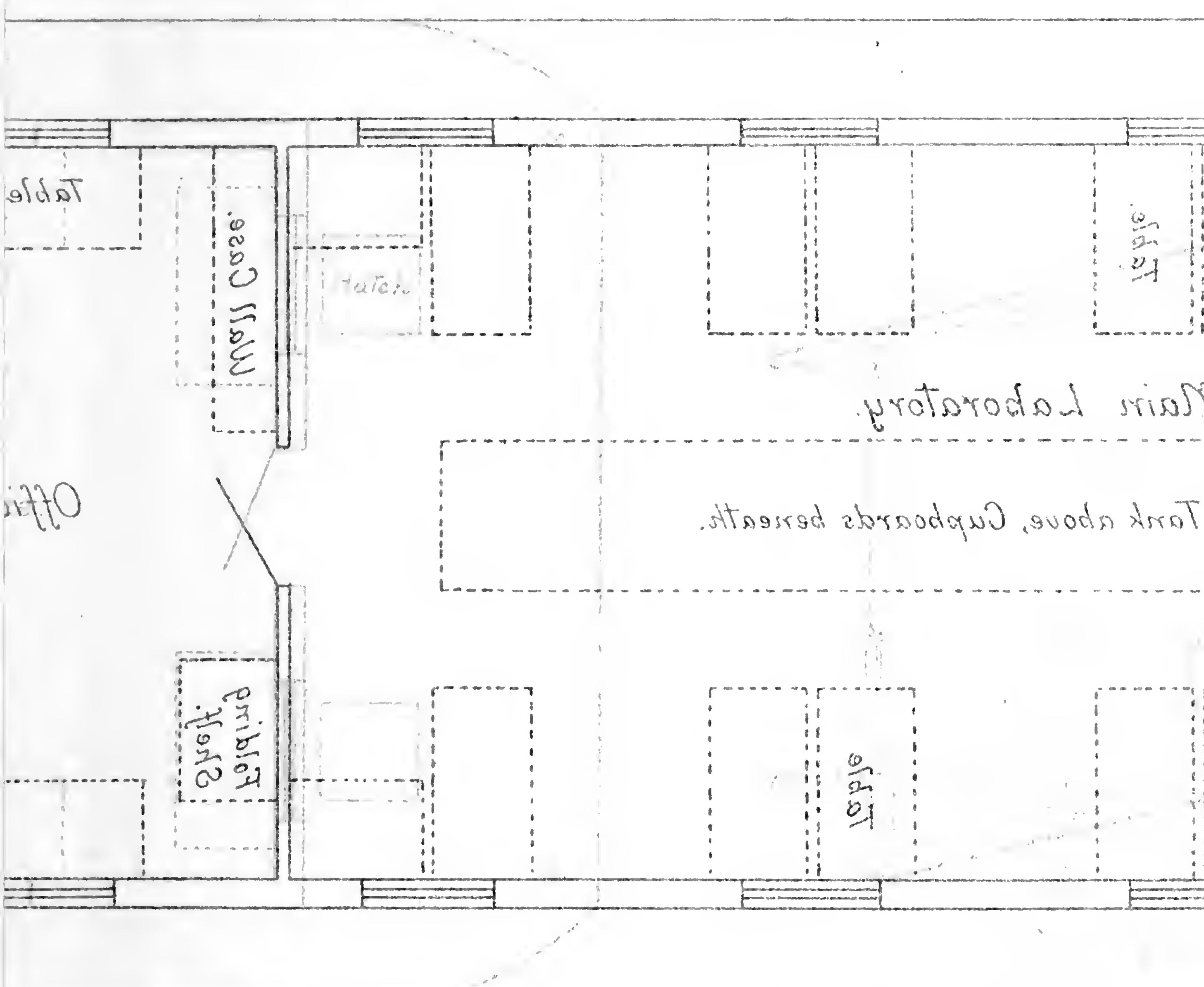
CABIN BOAT, QUIVER LAKE.



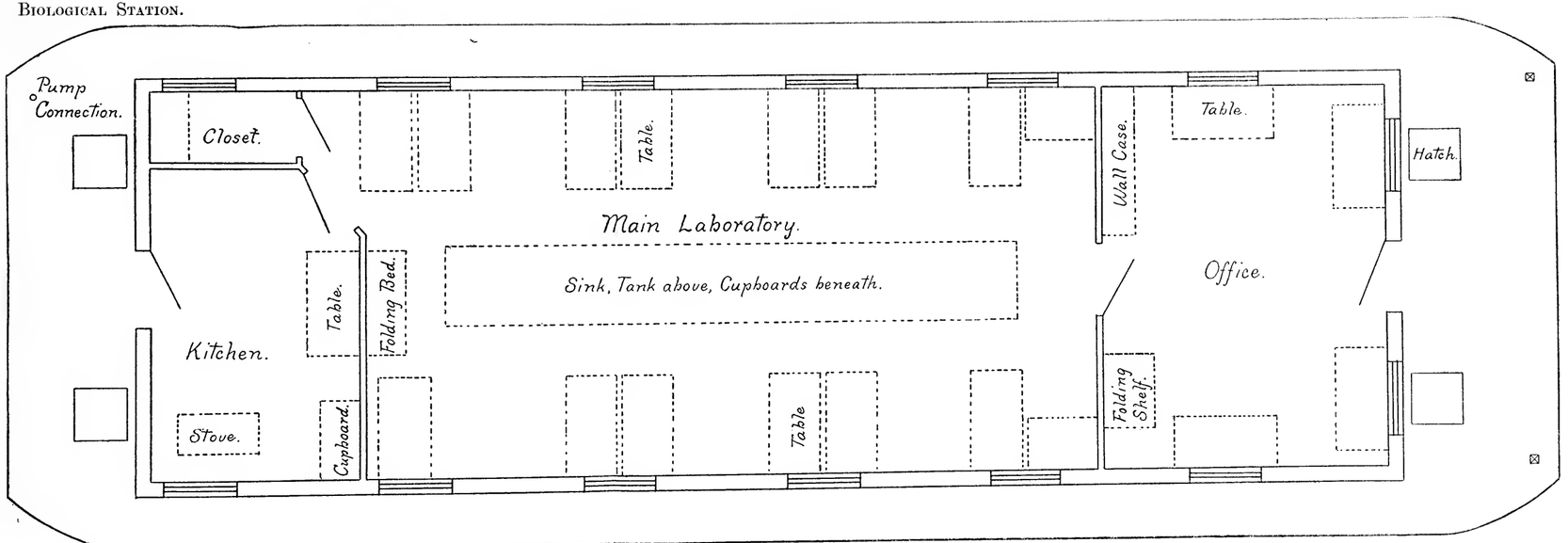
MAIN ROOM OF LABORATORY BOAT.



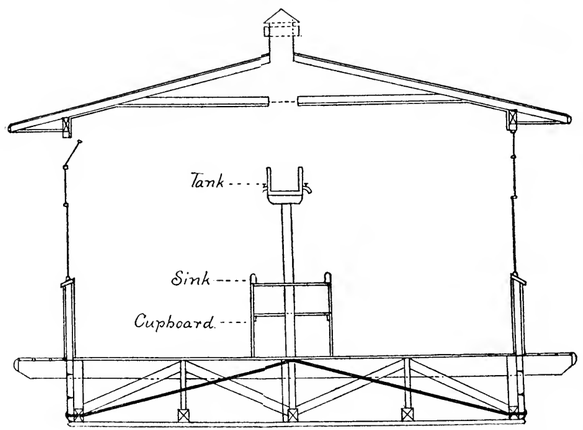
STAFF ROOM IN LABORATORY BOAT.



Plan of Cabin.

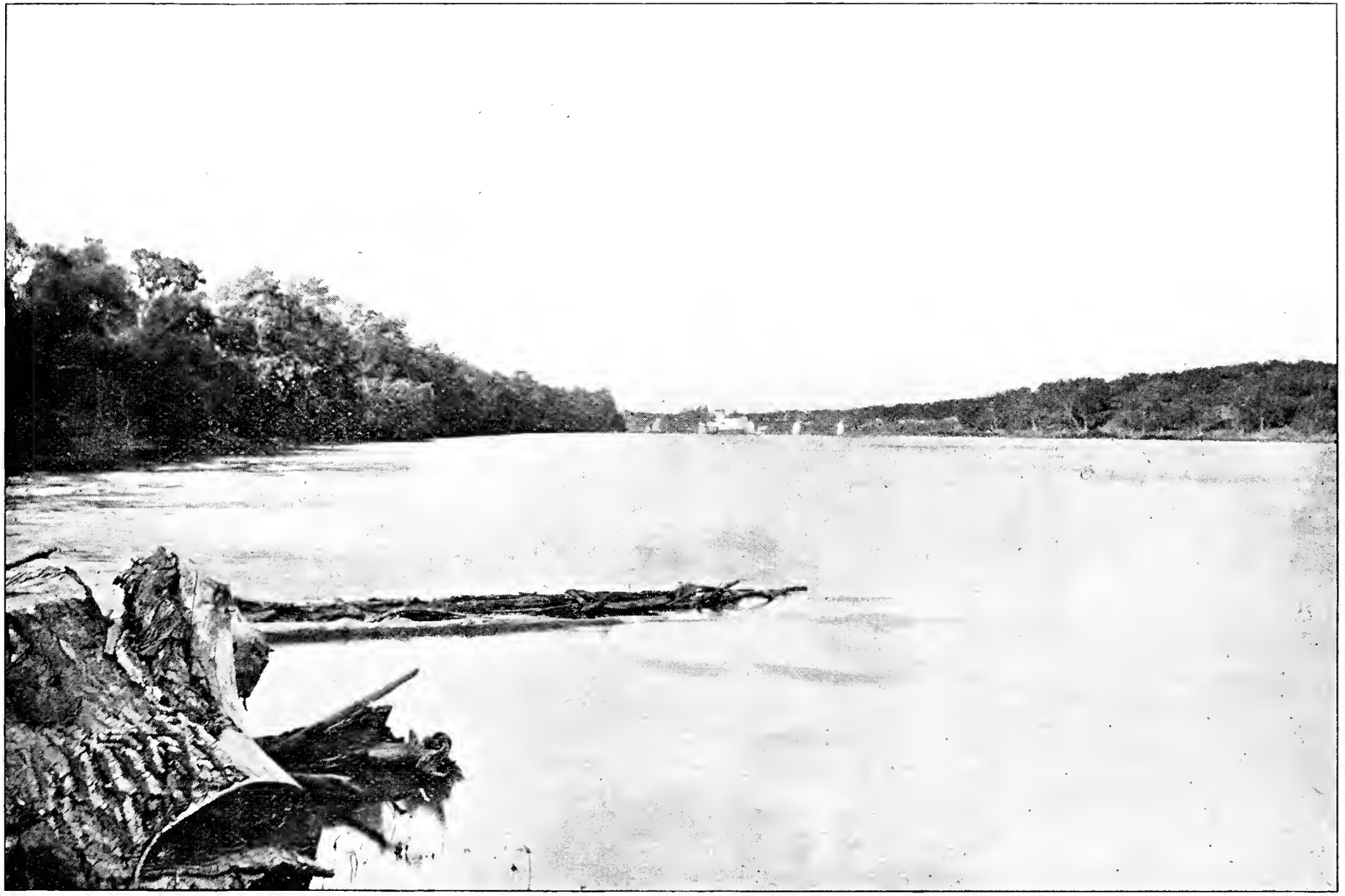


Plan of Cabin.

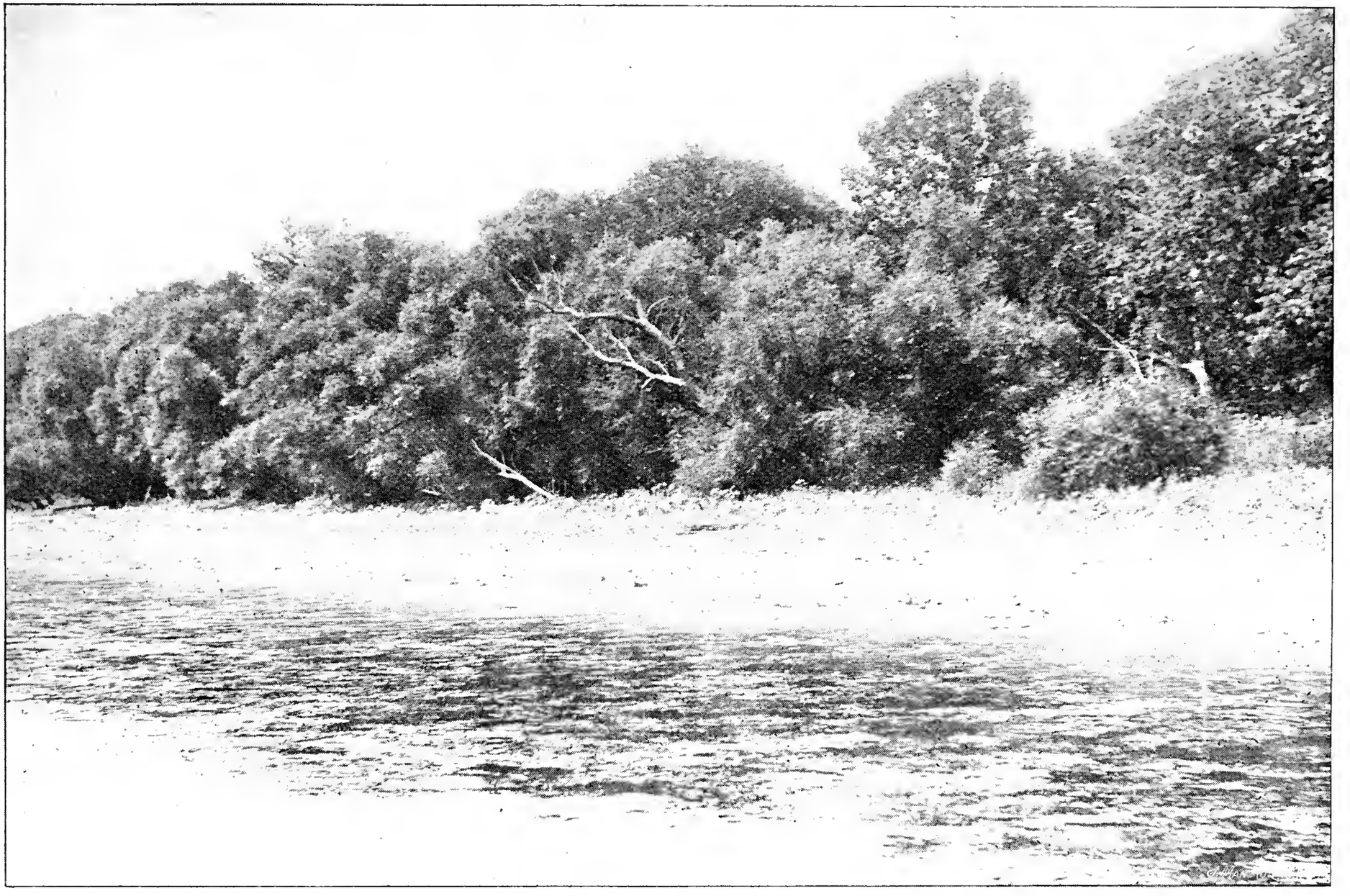


Cross Section of Cabin.

TAKING A PUMP PLANKTON, ILLINOIS RIVER.

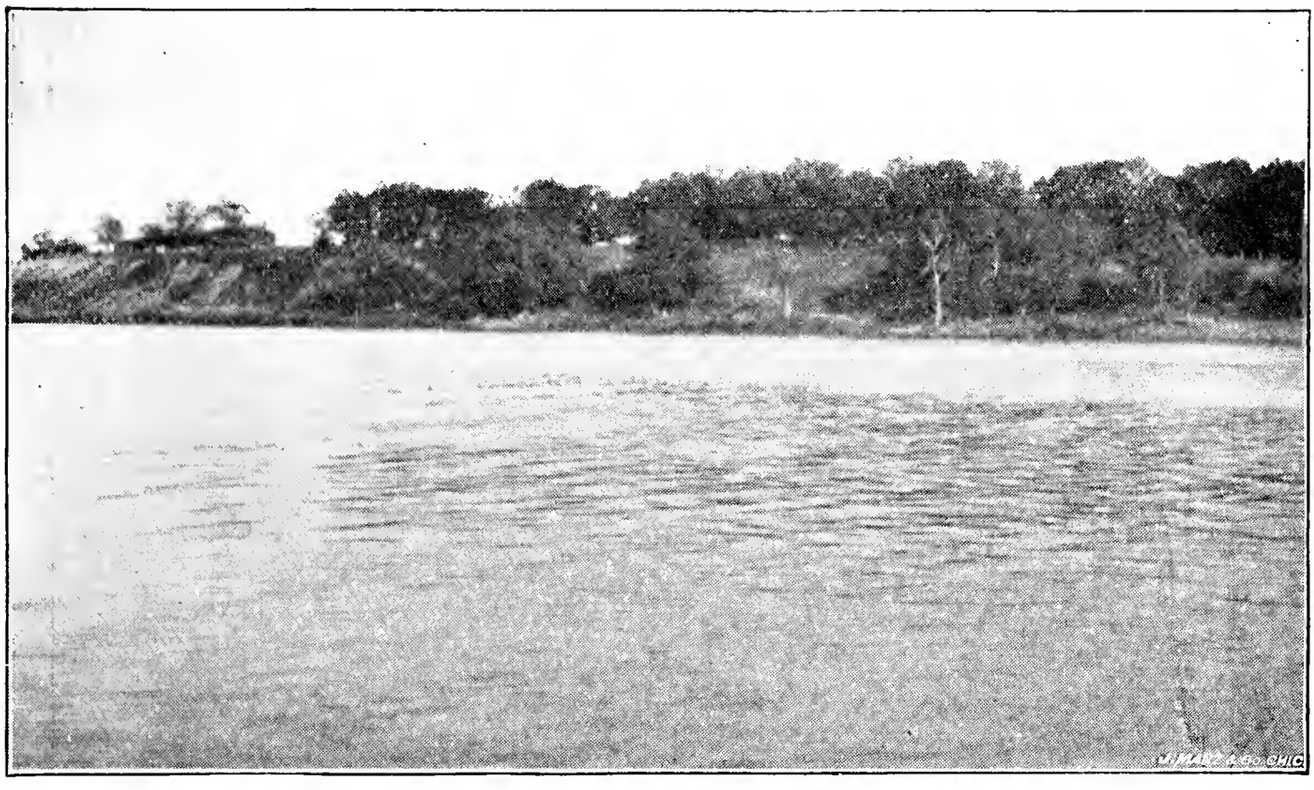


ILLINOIS RIVER, LOOKING NORTH TOWARDS HAVANA.



WEST BANK OF RIVER. SUBSTATION E.

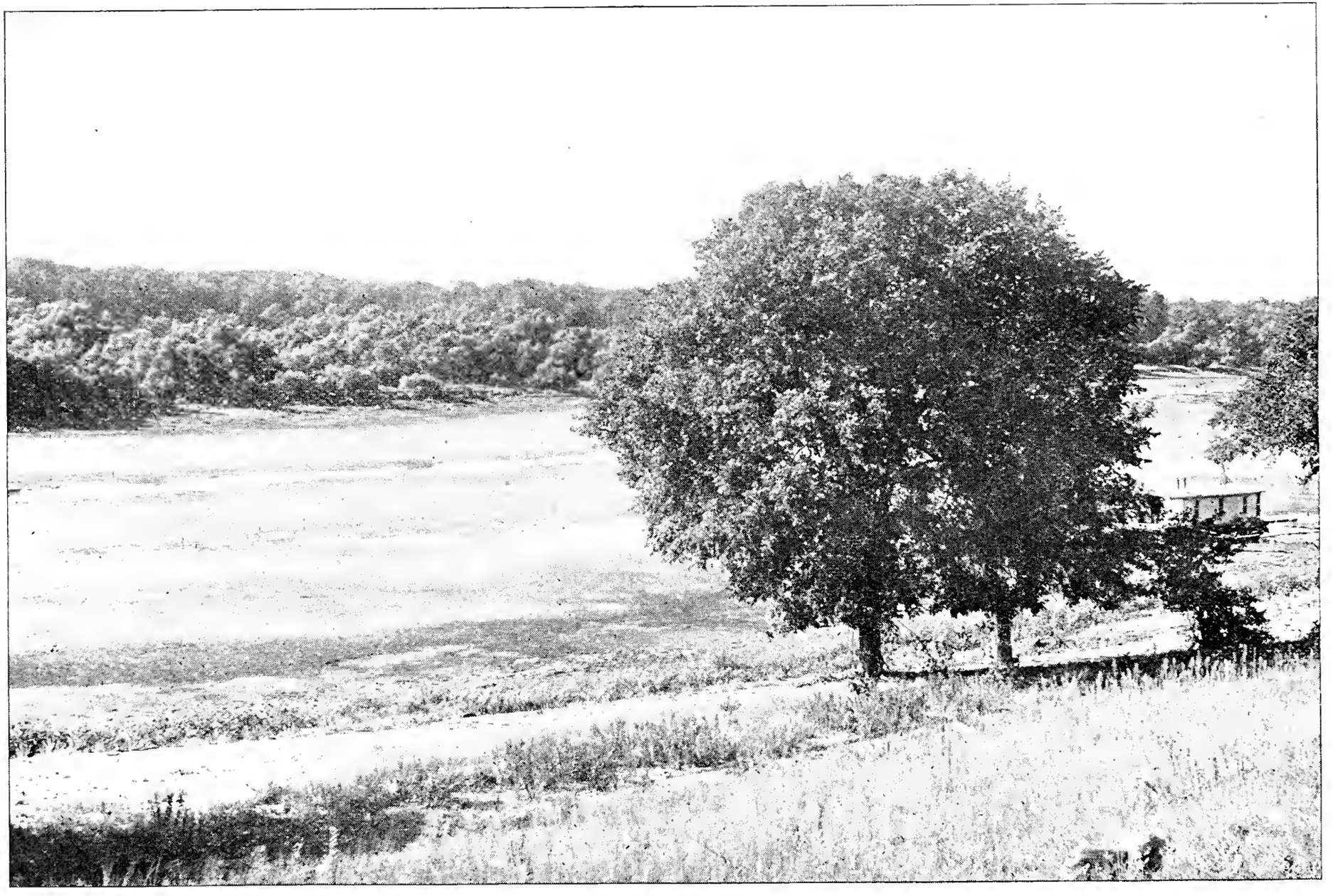
EXPOSED SLOPE OF WEST RIVER BANK AT LOW WATER.



EAST BANK OF ILLINOIS RIVER. SUBSTATION II.

STATION LAUNCH, IN QUIVER LAKE.

EAST BANK OF QUIVER LAKE. TWIN MOUNDS.



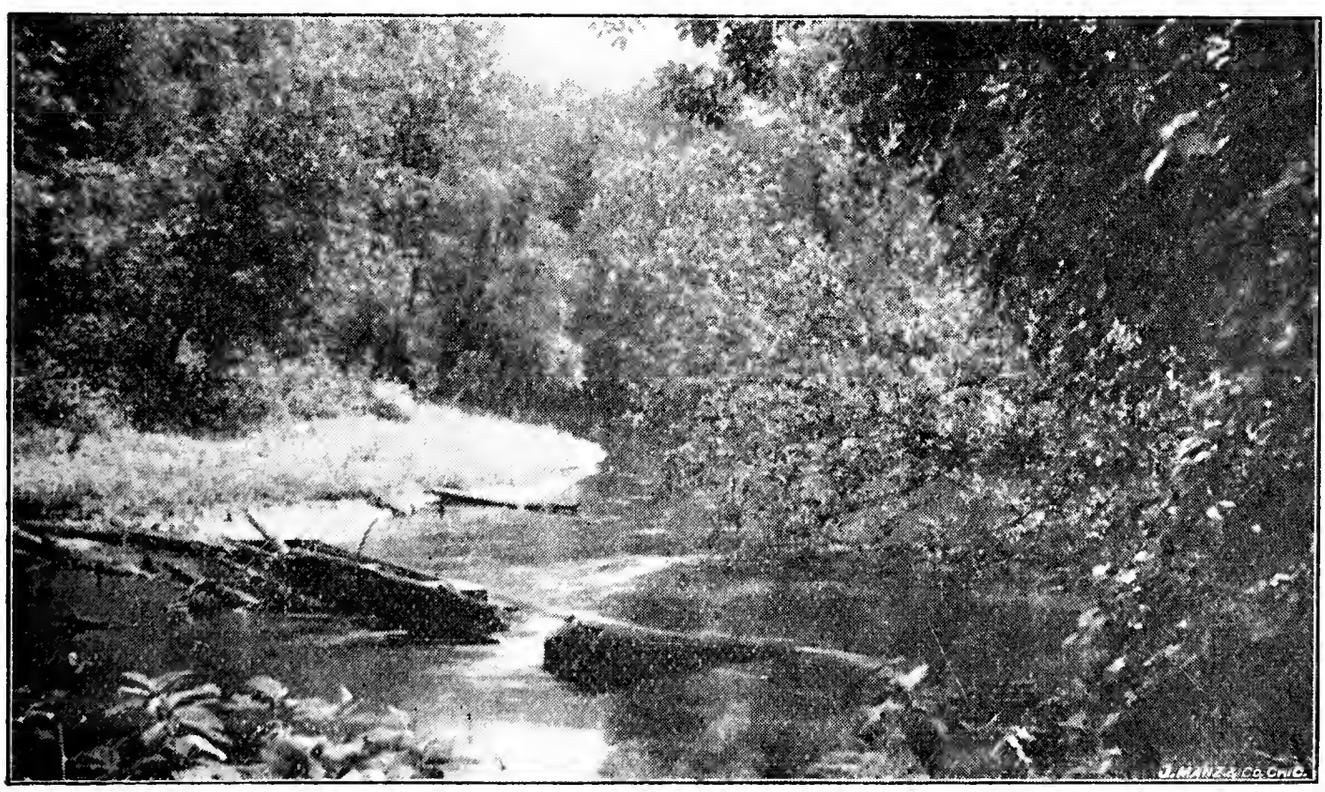
QUIVER LAKE, SUBSTATION C. MIDSUMMER.

DOGFISH LAKE. MIDSUMMER.

FLAG LAKE, LOOKING NORTH.

THOMPSON'S LAKE, LOOKING SOUTH.

DEEP SLOUGH, NEAR MATANZAS LAKE.



QUIVER CREEK, ONE MILE FROM LAKE.

SPOON RIVER, NEAR ITS MOUTH.

BOTTOM-LANDS AT HIGH WATER.

BOTTOM-LAND FOREST, NEAR MATANZAS LAKE.